Report of the Floodplain Group
CALFED ISB Adaptive Management Workshop
19-20 March, 2002

Prepared by:
Ted Sommer and Randall Mager, California Department of Water Resources
Jeff Mount and Peter Moyle, University of California at Davis
Elizabeth Soderstrom, Natural Heritage Institute

May 2002

Background

Floodplain inundation is one of the major factors that has shaped the geography, flora and fauna of California's Central Valley. As in most developed regions of the western United States, the majority of the historical floodplain has been lost to dam and levee construction (Mount 1995). However, California was fortunate in that early flood engineers retained relatively large areas of floodplain as part of the flood management system. The largest contiguous floodplain areas are the Yolo and Sutter bypasses, but substantial areas also exist as a result of levee setbacks in areas such as the Feather and American Rivers, and in recent restoration projects such as the Cosumnes River. Recent research in some of these locations indicates that floodplain inundation provides major benefits to aquatic species including:

- Increased spawning habitat (Sommer et al. 1997; Moyle, unpublished data).
- Increased fish production (Sommer et al. 1997).
- Increased rearing habitat (Sommer et al. 1997; Sommer et al. 2001a.Moyle, unpublished data).
- An enhanced food web within the floodplain (Sommer et al. 2001b; Mueller-Solger et al., In press).
- Food web support to downstream communities (Schemel et al. 1996; Sommer et al. 2001b; Schemel et al. In review).

Based in part on these observations, CALFED (2000) included floodplain restoration as a key component of the Ecosystem Restoration Program. Examples of potential restoration actions under CALFED include improving connectivity between floodplain and river channels, expanding the acreage of floodplain through levee setbacks or removal, and development of more "natural" habitat features on heavily altered floodplain (e.g. agricultural).

During the March 2002 CALFED Adaptive Management Workshop, the Floodplain Panel discussed sites for restoration or rehabilitation of floodplain habitat as possible locations for adaptive management projects. Alternatives included floodplain along the lower Cosumnes River, newly constructed floodplains on the Tuolumne and

Merced Rivers, and floodplain in the Yolo Bypass (Figure 1). The Yolo Bypass was chosen since it best site fit the principles of adaptive management elucidated in the workshop:

Concepts must be scale dependent: While small-scale study systems can be a useful source of information about the basic biology of some of the target species, evaluation of floodplain restoration ultimately requires large scale efforts to adequately address the major issues. Yolo Bypass has the advantage of a large area (24,000 ha) and relatively long inundation periods. An added advantage is that most of the available floodplain is currently under management for habitat preservation or wetlands protection by either private organizations or federal and state agencies.

High signal to noise ratio: Any action taken must have a sufficient signal-to-noise ratio to allow a reasonable probability that the anticipated system response can be detected. Observational studies of the Yolo Bypass have already shown statistically significant differences in the aquatic biota of river channel versus floodplain habitat. Detection of changes in lower trophic level biomass between the inlet and outlet of the floodplain has also been achieved. Therefore, we can reasonably expect that floodplain restoration projects should yield statistically useful data.

Implementation of the experiments should result in some form of ecosystem restoration: A guiding principle of the present adaptive management effort is that besides increasing system understanding, projects should also restore habitat. The Yolo Bypass represents a vast area of floodplain, the restoration of which could yield ecosystem level benefits.

Acceptable risk of structural change: In the Yolo Bypass, floodplain restoration actions would generally require minimal structural changes and those changes made would have a high degree of reversibility. Relatively minor structural changes would be needed to test many of the hypotheses for this system and could easily be returned to their original state if necessary.

Actions can take place a different scales: Projects within the Yolo Bypass could be either pilot projects or full scale restoration projects. Due to the high degree of reversibility, actions that produce positive benefits could be easily replicated over time or expanded in their scope.

Site Description

The Yolo Bypass is a 61 km long, 24,000 ha (59,000 acres) partially leveed basin that functions as the primary floodplain of the lower Sacramento River (Figure 1). It is inundated winter and spring for varying periods in about 60% of years, when it can convey up 14,000 m^3/s. Mean depth of the floodplain is usually less than 2 m, creating broad shoal areas. Water enters the top of the Bypass at the Fremont Weir

when Sacramento River flows exceed 2,000 m^3/s and from the Sacramento Weir when river flows exceed approximately 5,000 m^3/s (Figure 2). During dry periods when the Bypass is not inundated, the Toe Drain channel along the eastern edge of the bypass is inundated by tidal action, creating a permanent riparian corridor.

The Floodplain Panel recommended that the Yolo Bypass aquatic habitat restoration focus on the Yolo Wildlife Area, a property managed by California Department of Fish and Game (Figure 2). The Yolo Wildlife Area was originally developed as a 3,100 acre project, but in 2002 the area expanded to about 16,000 acres as a result of a habitat acquisition. Additional opportunities may also be available in land in Liberty Island in the southern Bypass, purchased in 2001 by U.S. Fish and Wildlife Service.

Project Goals

The measures considered for the Yolo Bypass are oriented towards enhancing native fish populations, especially salmon and splittail, while discouraging exotic species such as centrarchids and carp. The actions being considered will also enhance non-target species by increasing habitat diversity, terrestrial material input, primary production, and invertebrate production. In addition, these restoration goals will be embedded within an adaptive management protocol with the intent of reducing specific uncertainties associated with restoration of floodplain habitat for native species. Restoration of the Yolo Bypass under an adaptive management approach promises to provide an early-learning opportunity for application to other restoration sites.

Project Design

At the 2002 CALFED Adaptive Management Workshop the floodplain panel recommended that the Yolo Bypass project be designed to address two major restoration issues: 1) hydrologic regime; and 2) habitat/topographic diversity. These topics are summarized below.

Hydrology: Annual inundation is the principal force determining productivity and biotic interactions in river-floodplain systems (Junk et al. 1989). The Yolo Bypass Habitat Restoration Project will use a combination of natural flows and manipulated flows to determine the optimum frequency and duration of floodplain inundation for productivity native fish. The Bypass presently floods in approximately 60% of years during winter or spring for an average of about 20 days. The adaptive management project for Yolo Bypass is divided into four levels based on hydrology, summarized below and in Figure 3:

- No flow augmentation (“Critically Dry” water years).
- Fully controlled flow (“Dry” and “Below Normal” water years). All water for flooding within the project area would originate from new intake structures at

Fremont or Sacramento Weirs, or from smaller tributaries such as Putah Creek or Knight's Landing Ridge Cut.
- Partially controlled flow ("Below Normal" and "Above Normal" water years). The magnitude and duration of uncontrolled flood events would be extended within the project area using control structures or new intake structures.
- Uncontrolled flow ("Wet" water years). Complete inundation of the Bypass in extreme wet years would provide a high flow reference for the other hydrologic levels.

For all but the driest of water years, the bypass would be flooded in January or February, and water kept on the project area of floodplain through mid-April with a second pulse in April to aid emigration of salmon. Water would be drained off the floodplain by early May except for extremely wet springs. The response of aquatic species would be compared for each of the hydrographs, helping to inform future actions through adaptive management. To accomplish this project design, possible modifications could include:

- A low-flow notch in Fremont Weir allowing diversion of water from the Sacramento River. This would presumably require modifications to allow fish passage through the weir during low flows. Capacity of Tule Canal/Toe Drain might also need to be increased.
- Operational changes in the Sacramento Weir that would allow inundation of the project area in southern Bypass without flooding the northern section. Landowner issues could be greatly simplified by this approach.
- Conservation easements or other agreements with area landowners to allow increased flow through the Tule Canal/Toe Drain.
- Alterations to Lisbon Weir to allow greater control of flooding as well as improve upstream fish passage through the Tule Canal/Toe Drain.

Habitat/Topographic Diversity: Although ponds were a major feature of historical floodplains, recent surveys indicate that these habitats are dominated by non-native species (Feyrer et al. In prep.). These concerns led Sommer et al. (2001a) to hypothesize that floodplain habitats that seasonally dewater might offer the greatest benefits to native fish. This hypothesis is somewhat contrary to conventional ecological thinking that increased habitat and topographic diversity is preferable for restoration. To resolve this issue, the Floodplain Panel recommended that the adaptive management project include a mosaic of habitat types that could be compared. Habitats would range from well-drained, relatively homogenous areas (e.g. agricultural fields or grasslands) to topographically complex areas that include perennial ponds.

Opportunities

The Yolo Bypass is well suited for adaptive management. It is a large, highly visible project near a metropolitan center, close to agency and university support, with a

high potential for habitat enhancement with minimal alterations. The opportunities for adaptive management on the Yolo Bypass include:

Land: Through recent acquisitions, there is now over 16,000 acres available for habitat restoration by State and Federal agencies. Larger areas could potentially be included after coordination with local landowners and wildlife organizations. The area of floodplain that can be inundated is large enough to incorporate different habitat features.

Support: There is already a great deal of public support for restoration in this area. Through the establishment of the Yolo Bypass Wildlife Refuge Area and its associated stakeholder group (Yolo Basin Foundation), public, agency and private entities have worked cooperatively to establish management principles for the area. Actions taken would require coordination with this group, but all the actions discussed previously fit within the established management principles. There is also broad scientific support for restoration in this area and UC Davis is nearby for continued assistance and expertise.

Land Use: The proposed actions are reasonably consistent with existing land uses. Besides the DFG land in the Yolo Wildlife Area, substantial areas have recently been purchased in the southern Bypass at Liberty Island (USFWS) and Little Holland Tract (Audubon Society). Large areas are also managed for other wildlife, principally waterfowl by USFWS in a 2,500 acre property located near Sacramento Bypass**.** Other tracts are farmed for annual crops (rice, corn, wild rice) that have existing flood easements in place. Local stakeholder groups are generally supportive of restoration efforts within the wildlife areas.

Water: Procuring increased flows through dam releases for floodplain inundation on Sacramento and San Joaquin River tributaries is typically a major constraint to floodplain adaptive management. However, most of the water used to inundate the Yolo Bypass is returned to the river as it enters the Delta, so there is little net consumptive loss. Since water flowing through the Bypass is returned to the Delta before the major diversions, water rights may be less of an issue.

Flexibility: Successful adaptive management requires the ability to make adjustments to the project as the study progresses. Minor modifications to the Fremont Weir or changes in operation of the Sacramento Weir could drastically alter periods of inundation in the Bypass. Modifications to the Lisbon Weir, Fremont Weir, the Tule Canal and Toe Drain would affect fish passage to varying degrees. Most of these changes would be done incrementally and would be reversible if adverse effects are detected.

Low Cost of Error: The actions to be taken will involve changes in seasonal floodplain inundation and will not result in the permanent loss of resources or land. Since almost all the actions being considered are easily reversed, any adverse effects

detected through monitoring such as mercury methylation or organic carbon production could be addressed.

Availability of Baseline Data: Pre-project data is available through recent studies on Yolo Bypass. Data from ongoing studies on the Cosumnes River will also provide a reference and control to actions taken. Long term monitoring of the Delta by the Interagency Ecological Program and its agencies will also provide a good baseline to examine system-wide responses and background variability of the biota.

Time Scale: Previous research on Yolo Bypass and Cosumnes River suggests that lower trophic levels respond to floodplain inundation on the scale of weeks. Higher trophic levels such as fish or macroinvertebrates respond on the order of months. These time scales provide the opportunity to make adjustments between years or even within the seasons.

High signal to noise ratio: Through previous studies, it is apparent that experimental floodplain restoration studies will yield statistically useful data. Statistically significant differences in the aquatic biota of river channel versus floodplain habitat have been observed and detection of changes in lower trophic level biomass between the inlet and outlet of the floodplain has also been achieved.

Strong downstream benefits: Previous studies suggest that increased floodplain area and inundation may benefit the downstream Estuary. Adaptive management studies utilizing manipulation of flood flows, periods of inundation and extent of inundation may provide additional enhancement of the estuarine food web.

Compare/contrast with other sites: The results of studies can be easily compared with those taking place on other sites, especially the Cosumnes River. The Cosumnes River flood plain can serve as a control of sorts because it floods naturally on an annual basis , has a higher residency time of the water, and contains habitats lacking in the Yolo Bypass (e.g., mature flood plain forest).

Constraints

Existing Land Use: As a result of recent land acquisition, vast areas of potential habitat are available for aquatic habitat restoration and adaptive management. Nonetheless, adaptive management for aquatic biota needs to be compatible with existing land uses such as wildlife management. For example, the northern portion of the Yolo Wildlife Area has already been successfully developed for wildlife habitat; a major reengineering of this area for aquatic species is therefore unlikely. Similarly, the aquatic habitat adaptive management project needs to be compatible with the large areas of the Bypass that are still used for duck clubs and farming.

Regulatory Issues: Like other major restoration projects, adaptive management could be constrained by government regulations such as the Federal Endangered Species

Act, water rights (SWRCB), California Endangered Species Act, and Clean Water Act. Perhaps the major issue is flood control, under the state jurisdiction of the Board of Reclamation. Floodplain restoration activities must be compatible with flood management in the Central Valley. In practice, this means that restoration activities could not significantly affect conveyance, usually evaluated using hydrologic modeling. While increasing floodplain connectivity itself may be flood neutral (or even beneficial), allowing the development of substantial riparian or marsh vegetation could at least theoretically affect flood conveyance.

Water availability: Relatively little water is available within the Yolo Bypass for managed floodplain inundation. Small streams such as Putah Creek or Knight's Landing Ridge Cut could support modest floodplain projects, but landscape scale efforts ultimately depend on the availability of water from the Sacramento River.

Geomorphic Considerations: Different project configurations may not be feasible based on geomorphic considerations. For some areas, existing geomorphology and hydrology could make experimental floodplain restoration designs infeasible without structural changes. Site specific topographic and water surface elevation data are needed to address this issue.

Water quality: Although CALFED seeks to improve both water and habitat quality, some activities may be difficult to resolve. There is a reasonable expectation that floodplain restoration could result in at least slight increases in the loading of organic carbon and methylation of mercury, each a concern for municipal water quality. Pesticide loading could also be an issue if Knight's Landing Ridge Cut (which receives water from Colusa Drain) is a major hydrologic input to the floodplain restoration project.

Introduced Species/Biological Factors: Benefits of floodplain restoration could be partially or completely offset by introduced species. For example, our ability to maintain or manipulate experimental floodplain habitats could be lost if there is a proliferation of invasive plants. On relatively small streams such as Putah Creek, beaver activity could make it difficult to maintain the desired hydrologic characteristics.

Control Structures: Because of topographic or hydrologic constraints, control structures may be needed to emulate historical floodplain hydrology at some sites. For example, gates, weirs or partial levees have been used in other locations to regulate or enhance inundation of restoration sites. However, the use of control structures are often considered less desirable to fisheries management agencies since they can sometimes limit fish passage.

Species Benefits: Evidence to date suggests that floodplain restoration will have the greatest benefits to a few native fish species (e.g., splittail and salmon) that seasonally migrate into the Bypass. While some primary and secondary production

from the floodplain may reach the Estuary, it is uncertain whether there would be substantial benefits to other fish such as delta or longfin smelt.

Project Partners

Department of Fish and Game is the lead agency for the development of the Yolo Wildlife Area and will provide oversight for restoration efforts in Yolo Bypass. Since 2000, Department of Water Resources, Yolo Basin Foundation and Natural Heritage Institute have been developing some of the aquatic restoration concepts described in this proposal. In addition, U.S. Fish and Wildlife Service is presently developing plans for a refuge that would include the southern portion of Yolo Bypass. We propose that these groups (in conjunction with CALFED staff) continue to form the core of the project planning effort. DWR has staff funds for planning level work on Yolo Bypass through the CALFED Ecosystem Restoration Program; however, additional resources may be needed for the other partners. The major avenue for stakeholder input will be the Yolo Basin Working Group, funded by CALFED since 2000. The Army Corps of Engineers is presently working on their Sacramento-San Joaquin Comprehensive Plan for flood control; a central part of their plan is likely to include modifications to Yolo Bypass. As a consequence, ACOE may also be closely involved in the adaptive management effort.

Research and monitoring would continue to be coordinated by personnel of the Department of Water Resources, who have been collecting Yolo Bypass data since the mid-1990s. As in previous years, this work would be conducted in partnership with U.S. Geological Survey, U.S. Fish and Wildlife Service, UC Davis and DFG. A major recommendation of the Floodplain Panel was that the partnership with UC Davis should be expanded to include better coordination with the university's Cosumnes River floodplain restoration investigations. As a result, this project may eventually be associated with the UC Davis Center for Watershed Science.

Next Steps

This concept paper provides the overall justification for the project and some of the basic features that need to be included in the adaptive management project. At this point, our effort will focus on tasks related to project design, coordination, implementation, and monitoring.

Design. A more detailed conceptual model for the Yolo Bypass is needed that identifies the major ecological attributes of the system. This model will articulate the major uncertainties associated with the system in relation to a range of management actions. The conceptual model will also identify a suite of testable hypotheses about ecological responses to the restoration program. Following the development of the conceptual model, engineering will be conducted to establish the project design criteria and specifications.

Coordination. Coordination is needed between the Yolo Bypass adaptive management and other efforts to develop the region for habitat restoration and flood control. As discussed above, the project must continue to maintain close contact with groups such as ACOE, DFG, USFWS and Yolo Basin Working Group.

Implementation. Major steps for project implementation will include preparations of environmental documentation, obtaining the necessary permits and approval, securing funds for construction, selection of contractors and project oversight.

Monitoring. Over the next year we propose to develop a science-driven, sustainable research and monitoring plan. This plan would include establishment of close linkage between the Yolo Bypass and Cosumnes restoration projects, likely through UC Davis Center for Watershed Science.

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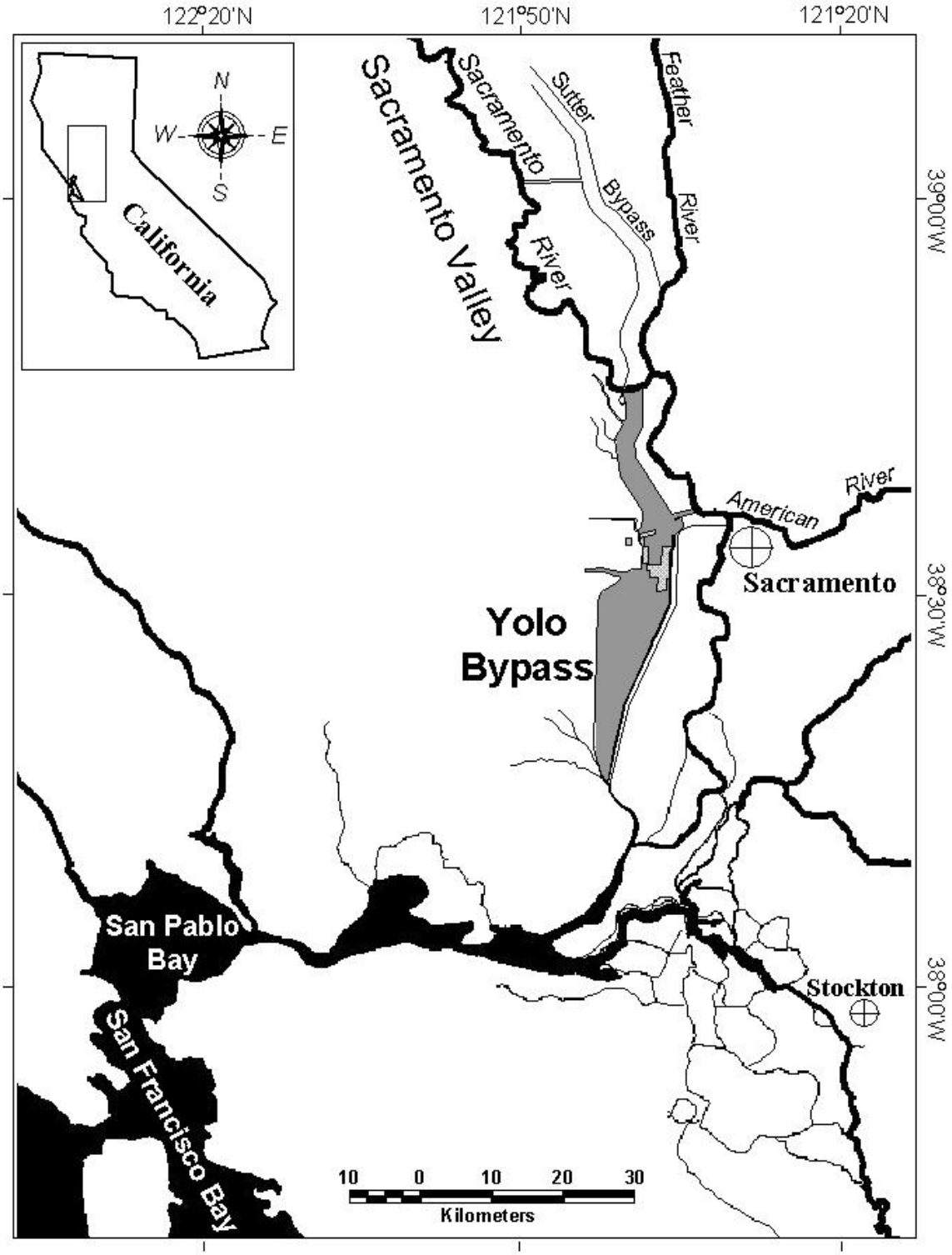
Figure 1: Yolo Bypass project area.



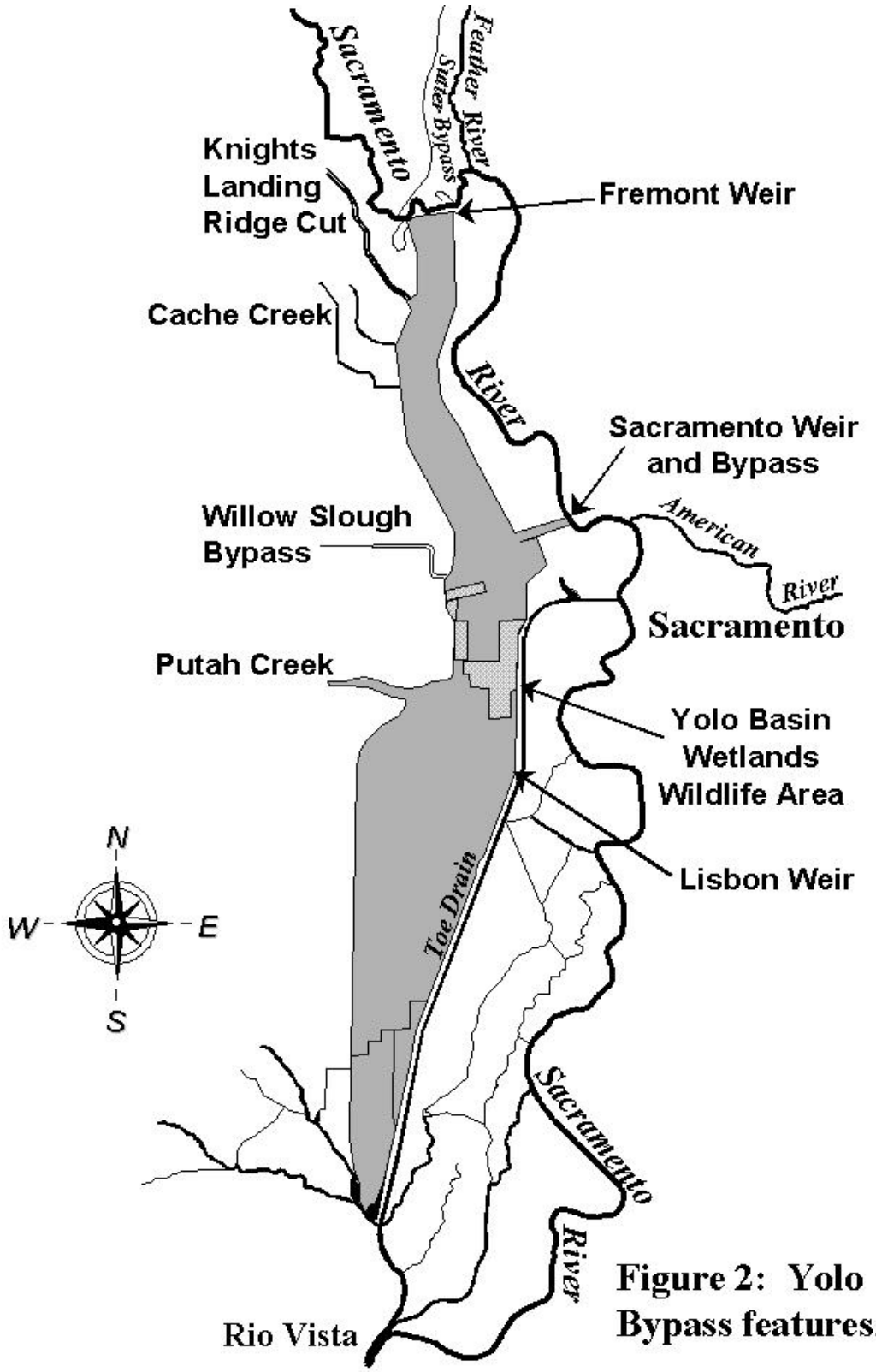


Figure 2: Yolo Bypass features.

Figure 3: Hydrograph for Yolo Bypass adaptive management.